

# FUEL CELLS: AN ENABLING TECHNOLOGY FOR FUTURE ARMY VEHICLES

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## Background

In the last decade, our dependence on imported oil and the continuing erosion of our environment have given new direction to government and industry. This concern and the desire to improve fuel economy and reduce harmful emissions have come to the forefront of action items to be studied by the departments of Defense (DOD), Transportation (DOT), and Energy (DOE).

With this current attention has come the opportunity to consider new technologies for the largest fleet of trucks: the one operated by the U.S. government. Thus, the Army and, indeed, the entire country face major challenges in relation to energy consumption and environmental compliance. The use of cleaner, more fuel-efficient vehicles is a formidable yet necessary goal for the military establishment and for commercial manufacturers. To help meet this challenge, the Army has taken a leadership role in establishing a research consortium between government and industry organizations to address these issues.

This article describes the fuel-cell research being conducted by the National Automotive Center (NAC), a

part of the U.S. Army's Tank Automotive Research, Development and Engineering Center, and covers some of the barriers, near-term and far-term goals, and expected end results of this research.

## Research Problem

Resolving environmental and fuel efficiency concerns while reducing U.S. dependency on foreign petroleum sources and introducing advanced technologies is not an easy task. Fuel constitutes 70 percent of the bulk tonnage needed to sustain a military force on the battlefield. This equates to 600,000 gallons of fuel per day, per division, at full advance. The situation clearly demands the development and deployment of clean alternative fuels and of new propulsion and other vehicle technologies that can compete with reliable, proven, and fully matured conventional products. Thus, there needs to be research and development (R&D) initiatives that concentrate on advanced propulsion technology, with a focus on advanced diesel engines, hybrid electric drives, and fuel cells.

A fuel cell is an electrochemical device that combines hydrogen fuel

and oxygen to produce electricity, heat, and water. Fuel cells operate without combustion, so they are virtually pollution free. The fuel cell itself has no moving parts—making it a quiet and reliable source of power.

The challenge of adopting fuel cells to military applications is daunting. Military vehicles will require the reformation of diesel or JP-8/5 military fuels with hydrogen gas, a technology that is still quite immature for the power levels needed on combat vehicles. Diesel fuel is very difficult to reform because its chemical nature, which promotes soot and tar formation, fouls catalysts and heat exchangers, and can eventually deactivate reforming and fuel-cell catalysts. Although the military is most likely constrained to using logistics fuels, fuel cells can provide a considerable degree of fuel flexibility; they can operate on hydrogen, methanol, ethanol, natural gas, and other hydrocarbon fuels.

Fuel-cell systems have the potential for Army applications because fuel cells are more efficient than internal combustion or diesel engines and have reduced emissions. While the fuel cell itself is the key

component, and an understanding of its features is essential, a practical fuel-cell system requires the integration of the fuel-cell stack with fuel processing, heat exchangers, power conditioning, water management, and control systems. The importance of each of these components and their integration cannot be overemphasized.

### Expected Applications

Many types of fuel cells have been developed and tested. Fuel cells have already been introduced in government-subsidized demonstrations and space-program applications. It should be noted that fuel cells have received a large amount of publicity, which has resulted in the false impression that they are in widespread use.

The NAC has anticipated, as a near-term application of fuel cells, the use of solid oxide fuel cells (SOFCs) as 3-10 kilowatt auxiliary power units (APUs) for trucks operating on diesel fuel. SOFCs could find application on commercial trucks and military vehicles as APUs for providing heat, air conditioning, on-board electronics, and refrigeration.

Historically, auxiliary power has been generated as parasitic power drawn from propulsion power, continuous engine idling, or lead-acid storage batteries. Diesel-fueled APUs have been developed for trucks and military vehicles to improve fuel efficiency, reduce engine noise and emissions, and reduce engine wear.

Although diesel APUs for trucks and military vehicles can reduce engine noise and emissions as well as increase fuel efficiency, there is room for considerable improvement. Furthermore, APUs are bulky, and for military applications, tend to be used on high-cost combat vehicles where the added cost can be more easily absorbed.

For certain military applications, lead-acid storage batteries are still used to provide auxiliary power when propulsion power is not required. However, problems with lead-acid

storage batteries include deep discharge, high cost, high maintenance, and the need to recharge the batteries.

New technologies that offer the potential to improve fuel economy and reliability, as well as reduce emissions and maintenance requirements, are needed. SOFCs, which are essentially solid-state devices with few moving parts, offer these benefits and should be considered candidates for improving APUs for trucks and military vehicles.

In the far term, the NAC expects fuel cells to become the main propulsion system or support for the propulsion system for trucks and military vehicles. One such application of the SOFC is to combine it with a gas turbine engine to form a hybrid engine, which permits internal fuel reformation. The approach would use the SOFC as a replacement for the combustor of a gas turbine engine. The SOFC is most efficient at partial power, and the gas turbine is most efficient at peak power, resulting in high combined efficiency over a broad power output range.

### Impact On Scientific Field

The NAC approach of incorporating fuel-cell technology into ground vehicles, and the methodology for testing and evaluating it, is zealously supported. Continued demonstration, evaluation, and simulation of fuel-cell technology will foster the acceptance of this new technology for future ground vehicles. This is evident because industry, academia, and other government agencies have also begun research into fuel-cell technologies. For example, DOD, DOT, and DOE are all involved in fuel-cell systems R&D. These agencies have initiated several fuel-cell projects and committed significant financial investments in fuel-cell research.

Fuel-cell engines are expected to meet the performance and range-between-refueling requirements of transportation vehicles, including

transit buses, automobiles, and trucks. This, together with much higher efficiency, improved fuel economy, and significantly lower emissions than the internal combustion engine or diesel, is expected to result in fuel cells capturing emerging world-market opportunities. In fact, fuel cells can be applied to all forms of transportation that use internal combustion engines: heavy-duty trucks and buses, locomotives, ships, passenger cars, light trucks, and vans. This application vastly increases the market for fuel cells and leverages their potential for global benefits.

A major hurdle for public acceptance of fuel cells is their current high cost. In the final analysis, bringing into account the enormous potential for energy that fuel cells present, environmental and economic benefits will depend on successful commercialization. The long-term prospects are indeed encouraging. The current commercialization focus is on further development of the technology, cost reduction, and high-volume manufacturing processes. Fuel cells are predicted to revolutionize new vehicles and will be implemented by almost all automakers around the world in the future.

The NAC plans on continuing its research in this active area of fuel-cell systems to observe where this new attractive technology can best impact future Army applications.

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